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Current sheets in front of geoeffective streams and flows as precursors of geomagnetic storms

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The number of current sheets observed at 1 AU depends on the corresponding type of the solar wind plasma flow or stream in which current sheets occur. Prior studies have shown that the maximum of the current sheet rate is detected in turbulent and hot flows and streams such as corotating/stream interaction regions (CIRs/SIRs) and the coronal mass ejection (ICME) sheath (Khabarova et al. JGR, 2021, https://doi.org/10.1029/2020JA029099). It is also known that the number of current sheets per hour begins to rise several hours before the arrival of potentially geoeffective CIRs/SIRs and ICMEs. This effect has been interpreted in literature as a crossing of so-called magnetic cavities filled with coherent structures (Khabarova et al. Sp Sci Rev. 2021, https://doi.org/10.1007/s11214-021-00814-x).

On the other hand, it is known that geomagnetic storms are preceded by ULF variations in the interplanetary magnetic field and solar wind density. We show that such ULF variations are associated with crossings of magnetic islands and current sheets inside magnetic cavities formed in front of geoeffective high-speed streams and flows.
A statistical analysis of the occurrence of current sheets prior to geomagnetic storms has been carried out employing the multi-year database of current sheets at 1 AU for 2011-2013 (see https://csdb.izmiran.ru) . 43 geomagnetic storms with Dst index lower than -50nT were detected during that period . The results show that there is an 80% increase in the number of current sheets before a geomagnetic storm commencement with a 10-hour advance time, on average. Therefore, current sheets can potentially be used as geomagnetic storm precursors.

A mid-term geomagnetic storm forecast technique using a Recurrent Neural Network for an automatic pattern search is proposed, based on this phenomenon. The minute data of the solar wind density, the number of current sheets, and the window Fourier transform results are taken as input data. Examples of the mid-term prognosis of geomagnetic storms are presented.